JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898

DETERMINING BIOLOGY TEACHER CANDIDATES' CONCEPTUAL STRUCTURES ABOUT ENERGY AND ATTITUDES TOWARDS ENERGY

Hakan Kurt

Abstract. *The aim of the current study is to investigate biology teacher candidates' cognitive structures related to "energy". As the research design of the study, the case study was applied. The data were collected from 44 Biology teacher candidates. The free word-association test, the drawing-writing technique and the semantic differential attitude scale were used as data collection instruments. The data were subject to content analysis and divided into categories through coding. In the analysis, the categories were formed and determined through the results of word-association test and drawing-writing test which were completed by the biology teacher candidates. With the help of these categories, the cognitive structures of biology teacher candidates were explained. These categories were determined as biological energy-metabolism, energy resources in the nature- types of energy- renewable energy and energy for life continuity. The semantic attitudes of Biology teacher candidates toward energy were found to be positive. On the other hand, it was determined that biology teacher candidates had misconceptions related to energy.*

Key words: *attitude, cognitive structure, energy, misconception.*

Hakan Kurt
Necmettin Erbakan University, Konya, Turkey

Introduction

The reasons why students are successful or unsuccessful in learning concepts are the leading issue in educational research for an effective learning. In this sense, concepts need to be structured appropriately in students' minds (Tartar & Koray, 2005). There exist many concepts pointed out particularly in different disciplines. One of these concepts is the concept of "Energy". The most basic definition of energy is the ability to perform a job in the Physics textbooks (Trefil & Hazen, 2004). Energy is also defined as a magnitude in different types of kinetic, potential, electricity, heat and nuclear energy. It is used for moving, heating and lighting, and it is calculated through its effects such as voice, heating and light (Sahan & Tekin, 2007). In Biology, it is a vital concept for living things, and its main source is the sun (Sagdic et al., 2007). Energy is a fundamental and pivotal concept that concerns many disciplines such as biology, physics, chemistry, and many other disciplines. In this sense, it leads students to have difficulty in forming conceptual structures related to energy (Stylianidou et al., 2002). The main reason is that the students try to establish relationships between the concepts and their daily usages. However, these concepts are mostly not related with the scientific equivalents, and that hinders learners to learn new concepts properly. Determining pre-knowledge of learners is necessary to change the false beliefs about why and how an action takes place, and renew the curriculum of science courses (Dekkers & Thijs, 1998; Osborne & Wittrock, 1983). The concepts are not concrete item, action or creatures. The concepts are abstract idea units categorized under some groups.

Particularly in recent years, the effect of constructivist learning on the educational contexts has revived conceptual understanding, different methods and strategies to be used in determining conceptual change. In this respect, there are some other techniques which determine students' cognitive structure and the relationships between the concepts, as well as find out whether these relationships are enough. These techniques become very crucial (Bahar et al., 2006). To this end, some strategies have been developed to induce and measure conceptual understanding, comprehension and change. Bahar (2003) provides these strategies as follows: word association, structured grid, diagnostic tree, concept maps, texts of conceptual change, analogy, and predict-observe-explain. On the other hand, some alternative techniques such as surveys, interviews, concept maps, fortune lines, and word association tests are used to determine students' opinions, understanding, or attitudes towards a specific issue (Bahar et al., 2008; White & Gunstone, 1992). In the current study, biology teacher candidates' conceptual structures related to energy, were investigated through versatile perspectives using free word-association test, drawing-writing technique in addition to semantic differential attitude scale.

The Studies Conducted on Conceptual Structures of Energy Concept

In this section, while providing literature mainly from *biology*, as energy concept is one of the fundamental concepts of many disciplines, the issue was investigated through reviewing studies conducted in different disciplines so that it is well-understood and comprehended. There are quite a few studies to determine the conceptual structures of students, teacher candidates, and teachers related to energy in biology discipline at any level of education. In this context, biology and science teachers and teacher candidates, as well as primary, secondary, high school, and university students, participated in the studies on energy in biology discipline, and these studies focused on photosynthesis and respiration (Al Khawaldeh & Al Olaimat, 2010; Bacanak et al., 2004; Brown & Schwartz, 2009; Cakiroglu & Boone, 2002; Carlsson, 2002; Cepni et al., 2006; Ekici et. al., 2007; Griffard & Wandersee, 2001; Gunes, 2011; Gunes et al., 2011; Kose et al., 2006; Keles & Kefeli, 2010; Lin & Hu, 2003; Tekkaya & Balci, 2003; Wang, 2004; Yenilmez & Tekkaya, 2006), revealing the participants' concept structures and determining that they had alternative concepts. These studies reveal that students can differently conceptualize the concepts of energy they encountered rather than scientific ones. Such pupils' conceptions are called misconceptions, preconceptions, alternative frameworks, children's science (Nakleh, 1992; Nicoll, 2001). While it was determined the commonly available misconception shared and stressed by university students is that ATP produced by cells uses only glucose as fuel available, high school students, as well as biology teachers and biologists, were found to have the misconception that ATP produced by cells is provided by only glucose (Oliveria et al., 2003; Da Luz, 2008; Da Luz et al., 2008). Energy is a concept emerging as a general feature of natural events. The preceding studies indicate that metabolic events could not be comprehended well.

The study conducted by Coban et al. (2007) revealed that only a small number of primary school students considered energy as the foundation of life. Concepts are not foundation of real life. They are foundation of our reflection of real life in our consciousness (Ayas et al., 1997).The great majority of the students provided kinetic and potential energy in the category of types of energy. One out of five of the students did not provide any response to the types of energy. The vast majority of the students responded that a glass of water, sound, battery and alarm clock had energy; however, they failed to express what types of energy these had.

It was determined that high school students also had some deficiencies in drawing categories such as energy save at home, energy resources, energy recycle, daily energy need, and solar energy (Ertas et al., 2011). Barak (1996), who evaluated high school Biology curriculum regarding to teaching energy, in another study, analyzed 10 grade students' explanations for such biological events as heat arrangements between living and non-living worlds, energy sources and photosynthesis as well as their concept structures, and suggested some solutions regarding teaching these subjects in biology curriculum (Barak et al., 1999). When university students majoring in physics, chemistry, and biology were asked to write analogies that reflect the role of energy in ecosystem, chemical reactions, mechanical systems, and electric loop, it was discovered that students used 7 different metaphors to explain for the role of

energy within different scientific contexts (Lancor, 2012). Moreover, Barak et al. (1997) investigated the concept of energy in their study in which high school senior students that enrolled in biology courses and biology teachers participated. The researchers proposed that the concept of energy affected the concepts of biology. They further divided the findings gained through the study into four sub categories as "components, processes, forces, and laws". It was revealed that biology teacher candidates also had a lack of knowledge regarding energy conservation and energy fragmention, that they confuse the concept of energy and that they considered energy concrete unit (Trumper, 1997a).

On the other hand, in the studies, it is stated that the overwhelming majority of university students provide explanations of the energy concept, and these definitions which might be accounted for rote memorization are not sufficient. Almost all of the students, although they know the concepts of energy save, provide responses as "Energy cannot be produced or destroyed". It was further determined that the majority of students failed to understand the concept of energy in biology since it was observed that many students provided the life processes available through photosynthesis in plants and digestion in animals and metabolism energy or this energy came directly from the sun. Two thirds of the students erroneously indicated that there is no energy involved/present in inanimate objects such as a statue (Chabalengula et al., 2012).

Moreover, the studies regarding the concept of energy *in chemistry*, indicate that primary, secondary, high school students and science education teachers have misconceptions with regard to heat and temperature, energy in chemical reactions and chemical bonds (Ahtee & Varjola, 1998; Aydogan et al., 2003; Ayyildiz & Tarhan, 2012; Baser, 2004; Boo & Watson, 2001; Ceylan & Geban; 2010; Coll & Taylor, 2001; Tan & Treagust, 1999; Harrison & Treagust, 2000; Niaz, 2006; Yesilyurt, 2006; Kirikkaya & Gullu, 2008; Kartal et al., 2011).

The studies on the concept of energy *in physics* stress that while the concepts of energy possessed by high school students are in conflict with scientific knowledge, and prevent scientific literacy and science learning (Svedholm & Lindeman, 2012), high school students have different misconceptions that are stated as "Energy can be seen through a powerful microscope and "Energy that is used is a force" (Hirca et al., 2011).

On the other hand, Watts (1983) categorized students' conceptual structures under 7 categories. These are, *firstly; students have considered energy as human-centered.* In this category, the objects that are related to humanity and contribute to humanity are discussed. *Secondly; they have viewed energy as a storage model.* In this category, energy has been regarded as a power source. Students view concepts such as water, battery, fuel, and sun as storage of energy. *As the third category; energy is a component and is not a necessary factor.* Energy is one of the dominant components in object and contexts. It needs some triggers that allow it to be free. Students stated that energy could not be stored in food and added that when food was consumed, it revealed energy. *As the fourth category; energy is an open activity.* While providing a definition of energy, they mostly considered energy as an outside activity. This activity is generally a movement. Students described these activities giving examples such as making a fire, giving a call, running, sledging, and anything that could happen in the world. They further stated that energy could not be reason for movement and added that energy created itself. *As the fifth category; energy is a product.* They, in this definition, put forward that energy was not a process or a factor. They preferred such waste products as cigarette some, sweating, and exhaust fumes. According to the students, clean energy is a case that is not protected and reduces life expectancy. When heated, ice melts, and the bonds between atoms are broken. When the bonds between atoms are broken, energy is reduced, rather than increased. *As the sixth category, energy is functional.* Energy is considered as fuel in many examples. Sometimes it can be limited. Energy can be limited more or less through technical implementations. Although not all these are necessary, it is generally a related case to lead a comfortable life. *As the seventh factor; energy is a run-off model.* It can never be transmitted from one to another as a cycle. They stated that energy could be transferred.

Since energy is an interdisciplinary concept, there have been enormous studies of students' alternative conceptions and effectiveness of alternative interventions. Since most of the scientists even describes this concept as 'Energy is the capacity of a physical system to perform work' or 'capacity for doing work' or 'capacity to produce change', a consensually accepted scientific definition has not still

been produced. Despite this disadvantage, several perspectives associated with the concept 'energy' have been investigated: energy and its description, energy conversion, and teaching and/or learning energy (Kurnaz & Calik, 2009).

As can be seen through the aforementioned statements, many students from primary school to university and teachers have difficulty in forming conceptual structure of the concept of energy, a crucial factor that is valid in many disciplines. Liu & Mceough (2005) stated that students had difficulty as energy is an abstract concept. They also stressed that the main reason of this difficulty was closely related to cognitive development process, maturation and the teaching-learning activities provided on energy in schools. In this context, there are many techniques that help determine individuals' conceptual structures. In the following section, the examples are provided from the studies particularly conducted in biology through explaining the techniques used in the current study.

Free Word-Association Test

Free word-association test is one of the most general and the oldest techniques that investigate students' cognitive structure. Used in many studies (Bahar et al., 1999; Bahar & Ozatli, 2003; Nakiboglu, 2008; Ozatlı & Bahar, 2010) this technique is quite efficient in revealing individuals' cognitive structures and conceptual changes (Hovardas & Korfiatis, 2006). When the related literature is revised, it is observed that there are also important studies in biology using free word-association tests. In Biology field, Kostova and Radoynovska (2008) investigated the cognitive structures related to "cell" and "biodiversity" of teachers and high school students with varying levels to find out their cognitive structures and levels of knowledge. They (2010) also studied high school students through the concept "humankind". Furthermore Dikmenli (2010a) investigated biology teacher candidates through "biodiversity" and through the concepts "science" and "scientist" (2010b), Dikmenli (2010c) investigated university biology students through "global warming" in another study. Trumper (1997b) studied primary school students through the concept of "energy" to find out these participants' cognitive structures and levels of knowledge. Through applying free-word association tests, the studies, while investigating students', teacher candidates', and teachers' conceptual structures, revealed that they also had alternative concepts.

Drawing-Writing Technique

Drawing-writing technique is an efficient technique used to reveal the students' learning thoroughly. This technique is very crucial in that it helps collect natural and high quality data on students' latency thoughts, understanding, points of view, attitudes, etc. (Garland, 2005; Levin & Bus, 2003; Pridmore & Bendelow, 1995). Furthermore, since drawing technique is more convenient in terms of time management than the other methods such as writing and behavior scales used to reveal opinions, understanding, and attitudes changes, and it enables collecting data from various perspectives, drawing technique is very effective. It is also efficient as it can be easily internalized.

There are many studies using *drawing technique*. In this regard, the following can be provided as examples for the research using drawing technique: university students' misconceptions related to respiration in plants and photosynthesis (Kose, 2008), high school students' mental models of environment (Shepardson et al., 2007), teacher candidates' views on the nature of science in ecology and genetics (Jordan & Duncan, 2009), primary school students' views on environment and conceptual models (Barraza, 1999), high school students' levels of conceptual understanding of the subject of cell (Yorek, 2007), university freshmen chemistry students' levels of conceptual understanding of chemical reactions (Nyachwayaa et al., 2011), science education teacher candidates' mental models of basic chemistry issues (Yayla & Eyceyurt, 2011), primary school students' conceptual understanding of energy save (Edens & Potter, 2003), primary school students' statements regarding endocrine and excretory systems (Prokop et al., 2009), and primary school teachers' views on energy (Kruger, 1990). In these respective studies, the misconceptions regarding the concepts studied were determined, and the participants' mental models were revealed.

There are also many studies using *drawing-writing technique*. In this regard, these studies were conducted on issues such as illness and health for high school students (Piko & Bak, 2006), water cycle and environment for primary school students (Dove et al., 1999), health education for high school students (Backett-Milburn & McKie, 1999), air pollution for primary school students (Pluhar et al., 2009) and heart for science education teacher candidates (Bahar et al., 2008), and primary school teachers' levels of understanding the biological concepts of gas exchange in photosynthesis and respiration processes (Lenton & McNeil (1993).

Attitudes towards the Concept of Energy

In literature, attitude is defined as "the core of human individuality", "the permanent organization of an individual's motivational, emotional, perceptional and mental processes towards an event or a psychological object", "positive or negative sensual intensity", and "learned tendency" (Bohner & Wanke, 2002; Fishbein & Ajzen, 1975; Muller, 1986; Tezbasaran, 1996). Attitudes, through cognitive, emotional and behavioral dimensions, play an important role in individuals' learning (Anderson, 1988; Bagozzi & Burnkrant, 1985; Bloom, 1979). It is a long and important process to lead individuals to adopt and change attitudes since cognitive, emotional, and behavioral factors affect how individuals adopt attitudes. At this point, the attitudinal and behavioral patterns are composed of four factors: Action, target towards action, content towards action and time. The general or special pattern of these four factors also forms the attitudes towards action (Ajzen & Fishbein, 1977). Thus, determining attitudes is important to the teaching method to be followed while leading an individual to adopt behavioral aims as it is widely known that there is a positive relationship between cognitive success and emotional success (Bloom, 1979). Attitudes can be measured through direct or indirect measurement techniques (Kagitcibasi, 2010). In the current study, Biology teacher candidates' attitudes towards energy were investigated through applying semantic differential attitude scale for the concept of energy. It is determined that the studies on the attitudes towards energy generally focus on certain issues. In this context, there are studies on the issues such as developing a scale for attitudes towards energy (Dulski et al.,1995; Ekici et all, 2013; Seyihoglu & Yarar, 2010); attitudes towards energy (Barrow & Morrisey, 1987; Kuhn, 1979; Lawrenz & Dantchik, 1985; Lloyd & Morrisey, 1987; Midden & Verplanken, 1990; Vlahov & Treagust, 1988); attitudes towards nuclear energy (Bisconti, 2000; Hinman et all., 1993; Komiya et al., 2008; Ozdemir & Cobanoglu, 2008; Yang & Anderson, 2003); attitudes towards knowledge about the concept of energy and energy use (Owens & Driffill, 2008; Lutzenhiser, 1993); interest towards solar energy (Faiers & Neame, 2006), and attitudes towards bioenergy (Nyrud et al., 2008).

Significance of the Research

As can be seen in the studies, at each and every level of education, students and teachers had many alternative concepts. At this point, through applying a triangulation and using free word-association test and drawing-writing technique, teacher candidates' conceptual structures can be determined, and their alternative concepts can be revealed. However, in the literature review on this issue, it is found out that there are a few studies using both free word-association test and writing-drawing technique to reveal biology teacher candidates' conceptual structures related to "energy". Therefore, it is believed that the results of the current study conducted through using free-word association test and drawing-writing technique will fill this gap in the literature providing data of quality. Moreover, there is not any study that investigates biology teacher candidates' semantic differences towards the concept of energy, and thus, it is believed that the data collected in the current study will contribute to the literature. Therefore, the current study is considered important as the results are gained through the participation of biology teachers and using free word-association test, drawing-writing technique and semantic differential attitude scale towards the concept of energy.

The aim of the Research

The aim of the current study is to investigate biology teacher candidates' cognitive structures related to "energy".

Methodology of Research

The free word-association test, the drawing-writing technique, the semantic differential attitude scale was used, and case study was applied as the research design of the current study. Case study is a research design that is in the foreground to reveal how a group sharing similar characteristics reacts to a certain situation. According to Yildirim and Simsek (2006), case study is the research method that aims to provide the opportunity to view a fact through the related individuals' perspectives and put forth the cases that are related to these perspectives. In this research design, through three types of data collection instruments, it is investigated how teacher candidates perceive the concept of energy and how their cognitive structures evolve.

Participants

The study was comprised of 44 Biology teacher candidates studying in the 4th and 5th grades of Ahmet Kelesoglu Faculty of Education in Necmettin Erbakan University in the spring term of 2011-2012 academic years.

Data Collection

These types of measurement tools were used as the data collection instrument in the current study. These are: free word-association test, drawing-writing technique and semantic differential attitude scale of the concept of energy. The basic aim of using different measurement tools in the study is to collect rich data through data triangulation (Yildirim & Simsek, 2006). Since it is stated that using different data collection methods in the same study increases the consistency, intelligibility and actuality (Glesne & Peshkin, 1992; Patton, 2002; Poggenpoel & Myburgh, 2003; Roberts et al., 2006; Shenton, 2004).

A free word association test: A free word association test is a technique which aims to determine a student's or a group's conceptual framework. The principal aim of this technique is to present the words as stimuli to the participants one by one in each time (Atasoy, 2004; Atasoy et al., 2007). Free word association tests are one of the most frequently used and widespread techniques which aim to determine a student's cognitive structure and the relationships between the concepts in this structure; in other words, the information network, and to find out whether the relationships among the concepts in the long-term memory are enough or not. These tests have been used in many studies (Bahar et all., 1999; Ozatlı & Bahar, 2010). This technique is based on the process in which an answer is suggested to a word that is used as an independent stimulus without limiting the mind to any specific response (Bahar at al., 1999; Sato & James, 1999). The participants are required to provide concepts that come to their minds in this free word association test, during a specific time (40 seconds), the words that are provided as answers are subject to frequency distribution that is followed by an in-depth analysis. In this way, it is possible to determine the participants' descriptions and gather findings on the related meanings of the word used as a stimulus. These practices of using free word association tests help reveal the meanings related to various concepts used in studies (Daskolia et al., 2006). The word association test consists of two sections;

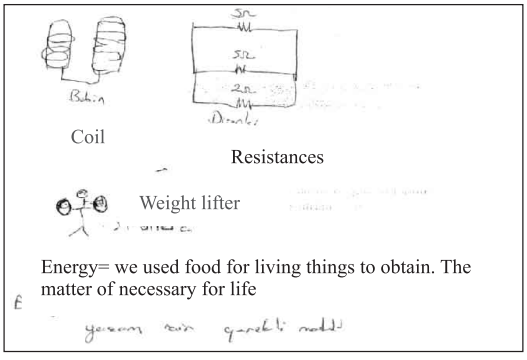
In the first section; the biology teacher candidates were asked to provide the very first 10 words that come to their minds in 40 seconds when they read or hear the concept "Energy". The key concept is provided one under the other in order to prevent sequential answering as they would just consider their answer and provide the words regarding that word rather than focusing on the key concept, which would threaten the validity and the reliability of the study. In this study, the concept of "Energy" has been

provided for the biology teacher candidates to complete the free word association test. In this test, the concept of energy has been provided in the following format as the stimulus word;

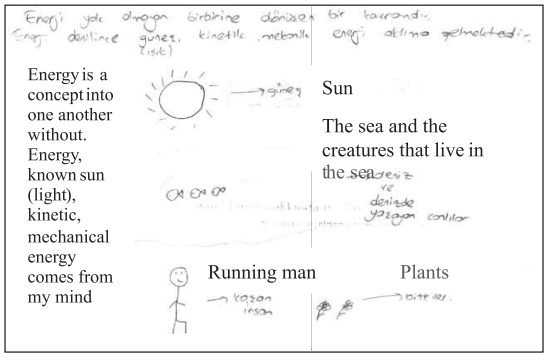
Energy -1 :……..
Energy -2 :……..
.
.
.
Energy -10 :……..

In the second section; the participants were asked to write sentences related to the key concept given in 20 seconds, and these sentences were carefully investigated while doing the data analysis since the answer provided in relation to the key concept can only be an answer of association that is not meaningfully related to the word. Moreover, the data analysis is directly affected by some cases such as whether the sentence is scientific and whether it includes different misconceptions considering the possibility that the sentence provided can be more complex and of high structure. The participants were asked questions such as "Please write a sentence on the concept of energy".

Drawing-writing technique: through this measurement instrument, it was aimed to investigate thoroughly the teacher candidates' views on the concept of energy (Rennie & Jarvis, 1995). This technique is very useful as during the study it helps collect natural and high quality data on latency thoughts, understanding, and attitudes (Backett-Milburn & Mckie, 1999; Pridmore & Bendelow, 1995; White & Gunstone, 1992). In this regards, the participants were asked to provide their views freely and without any limitation in 5 minutes to the question "What is Energy? What do you think about Energy? Please explain through drawing". The following are some examples of drawing-writing technique (Figure 1).



The answer sheet for P40



The answer sheet for P34

Figure 1: The examples of drawing-writing technique.

Semantic differential attitudes scale of the concept of energy: this scale was first developed by Osgood, Suci and Tannenbaum (Russell & Hollander, 1975). In this scale, 5 or 7 scaled score interval is used. It is a unipolar scale. It is a unipolar rating scale that is defined through two opposite attributes at opposing poles. In the current study, the scale was designed and applied to the participants as a 5-Likert style scale with appropriate adjectives suitable for the concept of energy. The adjectives were taken into evaluation as always, generally, sometimes, generally, and always. The scale asks the participants to rate the concept of energy according to their semantic differences and aims to reveal the participants' attitudes towards energy. In this scale, the participants select one of the adjectives at opposing poles considering its suitability for the concept of energy. In this context, the participants were given the semantic differential attitude scale related to the question "Which features do you find related to

the concept of energy?" The following are some example items from the semantic differential attitude scale of the concept of energy.

Valuable ..... □..... □ ..... □..... □…..□..... Worthless ....
Necessary ..... □..... □ ..... □..... □…..□..... Unnecessary

Data Analysis

For the data analysis, the participants' answer sheets were firstly numbered from 1 to 44. The data collected were analyzed through free word-association test and writing-drawing technique based on content analysis. The basic aim of content analysis is to reach concepts and relationships that can account for the data. To achieve this aim, similar data are collected and organized within certain concepts and analyzed in that readers will easily understand these (Yildirim & Simsek, 2006).

In the drawing-writing technique; however, the drawings and statements provided related to the concept of energy were analyzed in two different sections. The data were subject to content analysis. In order to achieve this, the statements of each participant related to the concept of energy were organized under certain categories and sub-categories within the section of the statements. The participants' drawings related to the concept of energy were analyzed in the same way. Moreover, in both free-word association test and drawing-writing technique, the interesting statements in the text provided by the participants were numbered and quoted within the sign " " (P30). In the drawing-writing technique, the examples of the drawings provided by the participants were numbered and provided in the text such as P40 and P34.

When the participants' views provided to the semantic differential attitude scale of the concept of energy were evaluated, the scoring was made through 1 to 5. In the bipolar scale, the positive adjectives were rated and evaluated as 5 points while the negative ones were rated as 1 point. According to this rating, the differences were found between the participants' positive and negative attitudes towards energy.

The internal validity of the categories and subcategories revealed throughout the study was assured through the author and the two experts in biology. Moreover, SPSS-15 was used to evaluate the semantic differential attitude scale, and Nvivo9.3 was used to create Model 1.

Results of Research

In this section, the data were analyzed according to the order in which the data collection instruments were used. Therefore, firstly the data collected through free-word association test were presented, then the data collected through drawing-writing technique, and finally the data collected through semantic differential attitude scale of the concept of energy.

The Data Collected Through Free Word-Association Test

As a result of the analysis of the data collected through free word-association test, 8 (eight) categories were specified through the words provided by the teacher candidates. In this regard, the categories and the words in each category were listed. When these words were meaningless and repeated only one, they were not joined with the other words. Therefore, 18.08% (66 words) of these mentioned words were not included in the categories. As a result, these words not listed in the subcategories were not provided in Table 1. Related to the word, energy, 56 words left were distributed among 8 (eight) categories. The words specified in each category and the categories were provided in Table 1. 399 words were specified in total.

Table 1. Associations with the concept "energy" (categories and answers included in each category and cumulative frequency of response words).

Main Category	Associations included in categories and their frequencies	Total frequency of associations in this category	%
- Biological energy-metabolism	"ATP" (27), "respiration" (13) "photosynthesis" (11) "metabolism" (8) "glucose" (7) "ADP" (5) "anabolism" (5) ""catabolism" (5) "phosphate" (5) "TCA (krebs cycle)" (5) "activation energy" (4) "activity" (4) "oxygen" (3) "basal metabolism" (2) "adenine" (2) "adenosine" (2) "glycolysis" (2) "chemocentesis" (2)	114	37.47
- Energy resources in the nature-types of energy-renewable energy	"action" (19) "solar energy" (17) "potential energy" (14) "kinetics energy" (13) ""nuclear energy"" (8) "renewable energy" (5) "heat" (5) "light" (4) "wind" (4) "chemical energy" (3) "mechanics" (2) "hydro electrical station" (2) "geothermal" (2) "non-renewable energy" (2)	100	33.45
- Energy for life continuity	"food" (10) "liveliness" (7) "life" (5) "water" (5) "fat" (4) "calorie" (2) "carbohydrate" (2) "protein" (2) "digestion" (2) "cooking" (2) "sports" (2)	43	14.39
- The units where energy is created-used for living things	"muscular" (6) "mitochondria" (6)	12	4.01

Main Category	Associations included in categories and their frequencies	Total frequency of associations in this category	%
- The physical aspect of energy	"power" (7) "speed" (2) "physics" (2)	11	3.68
- Energy flow-cycle-related events	"electric current" (5) "electron transferring" (2) "circulation" (2) "recycling" (2)	11	3.68
- The terms that recalls energy	"factory" (2) "disappearing" (2) "product-production" (2)	6	2.00
- The chemical aspect of energy	"chemical bonds" (2) "reaction" (2)	4	1.32
	General Total	**299**	

When Table 1 was examined, according to the findings revealed, in the first category, the related answers provided by biology teacher candidates in response to the concept of energy mostly fell into the category of "biological energy and metabolism" and appeared as the dominant category (f=114). In this category while most of the teacher candidates focus on the concepts "ATP", "respiration", "photosynthesis", "metabolism", "glucose", few teacher candidates link the following categories, "ADP", "anabolism", "catabolism", "phosphate", "Krebs cycle", "activation energy", "activity", "oxygen", "basal metabolism", "adenine", "adenosine", "glycolysis", and "chemocentesis". This result indicates that teacher candidates relate the concept of energy mostly with biological energy and metabolism in their cognitive structures. Moreover, the words that were provided in this category by the teacher candidates but not included in this category as they were stated only once are as follows: *active movement, carbon dioxide, ETS, FAD, GTP, and NAD*.

In the second category, teacher candidates linked to "energy resources in the nature, types of energy, and renewable energy (f=100). In this category, the words provided as answers by the teachers focused mostly on "action", "solar energy", "potential energy", "kinetic energy", and "nuclear energy". Few of the teacher candidates, on the other hand, provided the words "renewable energy", "heat", "light", "wind", "chemical energy", "mechanics", "hydro electrical station", "geothermal", and "non-renewable energy". Furthermore, the words that were provided in this category by the teacher candidates but not included in this category as they were stated only once are as follows: *thermal power station, running, anthracite coal, air*, and *heat*.

In the third category, the words provided by the teacher candidates were categorized under "energy for life continuity" (f=43). In this category, the teacher candidates stated the words "food" and "liveliness" more frequently than the words "life", "water", "fat", "calorie", "carbohydrate", "protein", "digestion", "food", and "sports". Furthermore, the words that were provided in this category by the teacher candidates but not included in this category as they were stated only once are as follows: "*food pyramid, plant, respiration, excretory system, growth, and reproduction, human, necessary for the body*, and *life*.

The fourth category was specified as "the units where energy is created and used for living things. The teacher candidates' linking this category were mostly on the concepts, "muscular" and "mitochondria". The teacher candidates' cognitive structures related to the units where energy is created and used for living things were not found to be enough. Furthermore, the words that were provided in this category by the teacher candidates but not included in this category as they were stated only once are as follows: *enzyme, chlorophyll, chloroplast, striated muscle*, and *heart*.

In the fifth category, the answer words provided by the teacher candidates were categorized under

"the physical aspect of energy" (f=11). The participants focused mostly on the concept of "power". They provided the concepts "speed" and "physics" less frequently. Moreover, the words that were provided in this category by the teacher candidates but not included in this category as they were stated only once are as follows: *waves, dynamic balance, change of state, raw material, performing work*, and *acceleration*.

The sixth category was specified as "energy flow, cycle, and related events" (f=11). The teacher candidates' answer words related to this category were found to be "electric current", "electron transferring", "circulation" and "recycling". Furthermore, the words that were provided in this category by the teacher candidates but not included in this category as they were stated only once are as follows: *release, current, battery, AMP, ampere, illumination, nature, natural gas, energy cycle, the tide, cell battery, transformer, and volt.*

The seventh category was determined as "the terms that calls energy" (f=6). The answer words provided related to this category were determined as "factory", "disappearing and "product-production". Moreover, the words that were not included in this category as they were stated only once are as follows: *natural gas bill, beverages, getting weight, preservation, national wealth, money, health, war, and commerce.* In this category, the teacher candidates were observed not to have any meaning relationships.

The eighth category was determined as "the chemical aspect of energy". The participants provided the concepts "chemical bonds" and "reaction". In addition, words related to chemistry such as "*chemist*" and "*matter*" was not included as they were not stated more than once.

On the other hand, some examples of the biology teacher candidates' statements related to the concept of energy, and analyses are provided below:

Through saying that "*Energy is gained through burning carbohydrate, protein, and fat, and helps life continuity*" (P17), the participant explained how living things acquired energy. When this teacher candidate's answer words were analyzed, the participant thought about the stages in which energy was generated in a living thing through the concepts "*respiration, glucose, ETS*, and *mitochondria";* however, did not state these in a sentence.

The participant (P28) stated that "*It is necessary for life continuity"* When the teacher candidate's answer words were analyzed, it was determined that this teacher candidate did not use the concepts in a sentence. The teacher candidate's answer words were "*ATP, ADP, AMP, sugar, phosphate, calorie, power, and construction-destruction*", indicating that the participant tried to state the energy cycle in a living thing.

The participant (P9) used the phrase ".... types of energy". The answer words were determined as "*action, sun, geothermal energy, anthracite coal, natural gas, active movement, respiration, photosynthesis, mitochondria*, and *TP*". When the sentence and the answer words provided by this participant are analyzed, it is observed that the participant provided only some of the energy resources and did not use the other words.

The participant (P3) provided the sentence, "*Plants transform the energy that they received from the sun into ATP*. *Energy is generated through respiration, and used in the body for metabolism*. "When the answer words are analyzed, it is seen that the participant used the words mentioned in the responses. It may be stated that this teacher candidate has a lack of knowledge since the candidate should have stated that in photosynthesis, just as solar energy could be stored as ATP, it also could be stored in the bonds of molecules as chemical bond energy.

The participant (P31) stated that *"Oils, carbohydrates and protein are used as energy resources. When we think of energy, ATP and the sun come into our mind. Plants, as a result of photosynthesis, obtain ATP".* When the answer words, "ATP, respiration, photosynthesis, oils, carbohydrates, proteins, cell destruction, cell construction, and phosphate", are investigated, it is revealed that the participant based the concept of energy on the types of food and energy. The teacher candidate, in his/her cognitive structure in which s/he did not have any unrelated links with the concept of energy, was found to have had a link with biological energy and metabolism.

The participant (P42) expressed that *"According to the first rule of thermodynamics, energy does not disappear.* It can be changed into one another." When the answer words, "*food, vitamin, ATP, Activation*

energy, speed, solar and nuclear", were analyzed, it appears that the participant did not use the words semantically.

The other statements provided by the teacher candidates are as follows:

"We should use energy resources in our country in the most effective and efficient way and economically"(P39)

"There is more than one energy resource in the world" (P40)

"Energy makes many parts of life easier" (P41)

In the overall analysis, it appeared that some of the teacher candidates did not write any meaningful sentence related to words, while some did not write any sentence. This might be attributed to the fact that they either did not want to write on purpose or did not write as they did not know. The great majority of the biology teacher candidates thought of energy within the context of biological energy and metabolism, which is what biology teacher candidates are generally expected to have links. However, energy resources in the category entitled "the units where energy is created-used for living things" are found to be less frequently selected by the participants compared to the category of "types of energy and renewable energy". The same situation is valid for the category entitled "energy for life continuity".

The Data Collected Through Drawing-Writing Technique

It is determined that the data collected through drawing-writing technique to investigate biology teacher candidates' cognitive structures related to the concept of energy fall into 8 (eight) categories in total. These can be listed as follows: biological energy and metabolism (43), energy resources in the nature, types of energy and renewable energy (30), energy flow, cycle and related events (9), the relationship of energy with daily life and technology, (3), the physical aspect of energy (12), the damage caused to the nature and society due to improper use of energy (4) and the chemical aspect of energy (2). When the statements provided by the teacher candidates were analyzed, it was determined that they mostly used the terms, vital activity (12), food breakdown (12) and solar/light energy (8). However, it is seen that in this context, the findings of drawing are divided into 6 categories, and the findings of writing are into 8 categories (Table 2).

Table 2. The findings of the categories and subcategories obtained through drawing-writing technique related to the concept of energy.

Main Category	Sub-category	Drawing (n)	Writing (n)
-Biological energy-metabolism	Food breakdown	-	10
	ATP	6	1
	Photosynthesis	2	3
	Respiration	2	4
	Anaerobic Respiration	-	4
	Oxygen	2	3
	Anaerobic respiration	-	2
	Carbon Dioxide	2	2
	ETS	2	2
	FADH2	-	2
	NADH2	-	2
	Total	17	43

Main Category	Sub-category	Drawing (n)	Writing (n)
-Energy resources in the nature- types of energy-renewable energy	Sun/Light energy	12	8
	Electric energy	-	7
	Kinetic energy	-	6
	Potential energy	-	5
	Wind panel	5	-
	Heat (energy)/Sun/Fire	3	2
	Water/Dam/ Hydro electrical station	2	2
	Thermal station	2	-
	Action/Running- human Acting/Commute between school and home	2	-
	Total	14	30
- Energy for life continuity	Life continuity/Vital activity	-	12
	Need nutrients/nutrients	4	5
	Source of life	-	4
	Life	-	3
	Child / Book / Candle	2	-
	Making life easier	-	2
	What a body needs	-	2
	The growth of plants		2
	Total	6	30
- Energy flow-cycle-related events	Plants	4	4
	Change of energy	-	3
	Animals	3	-
	People	3	-
	The flow of energy	-	2
	Electric cable	3	-
	Electric pole	2	-
	Total	15	9
The relationship of energy with daily life-technology	Technological tools	-	3
	Bulb	4	-
	Battery	2	-
	Television	2	-
	Computer	2	-
	Total	10	3
The physical aspect of energy	Performing work/power	-	7
	Conservation of energy	-	5
	Total	0	12
The damage caused to the nature-society due to improper use of energy	Air pollution	-	2
	Danger for living things	-	2
	Money / War	2	-
	Total	2	4

Main Category	Sub-category	Drawing (n)	Writing (n)
The chemical aspect of energy	Reaction	-	2
	Total	0	2
	General Total	64	133

Some examples of the statements provided by the teacher candidates related to the concept of energy are provided, taking the appropriate category into consideration as follows:

The example for the category of energy and metabolism:

"Energy is composed of the resources available in the body of living things and in the nature." The living thing must consume to live on. It achieves this through various ways. Energy can be used through generating it through the resources in the nature can be used through as there is a thermal station in the city where I live, the very first thing that comes to my mind is the factory chimney." I believe that it pollutes air, thereby causing people to become ill" (P2)

"*Energy is generated through food breakdown by respiration*" (P11)

"ATP comes to my mind when I say energy ..." P29

"... Energy is like the function of a battery. It is generated when food is broken down by metabolism" (P17)

"... Living things need energy to live on. They obtain this energy through the food they consume" (P12)

The example of the energy category of the energy resources in the nature, types of energy and renewable energy:

"... There are many types of energy used in daily life. Such as heat energy, potential energy, kinetic energy, electric energy..."(P28)

"Energy plays an important role for living things in growth, development and acting. Energy is a concept that does not disappear in the nature. Therefore, living things can use renewable energy for ever again and again"(P33)

The example of the category of energy for life:

"If we, for instance, suppose that an individual frequently commutes between school and home, the energy spent during this process comes to my mind" (P3)

"Energy is a need like our other needs. Energy, like water, does not disappear, but transforms into different types of energies. Just as all living things need water, energy is among these needs" (P4)

"The complex structure that has existed and has been constantly changing since the beginning of life has been improved and changed, and made life more livable. It is the base of sciences such as physics, chemistry, and biology. Thanks to energy, commerce, technology, and economy have developed. As a result of the developments, the world can be a dangerous place for humans and other living things like nuclear energy..." (P16)

".... if there were not any energy, there would be any life. ATP is the energy resource of human body The sun is the largest heat and light resource for the world..." (P25)

The example of the category entitled energy flow, cycle, and related events:

".. There is a constant energy flow between the living things in the world. Energy has never disappeared, but it changes. There is not any recourse...Energy is saved" (P22)

The example of the category entitled the relationship of energy to daily life and technology:

"When energy is pronounced, the very first thing that comes to my mind is electric energy. Electricity has become very important in each and every aspect of our life. TV, the Internet, illumination, all these have great importance in our life. I really wonder how ancient people lived without electric-

ity. I wonder what they did when it got dark. How were they dealing with washing, washing-up, TV etc?" (P37)

The example of the category entitled the physical aspect of energy:

"Energy is the power required for physical and chemical events to occur. It is the ability of performing work" (P14)

The example of the category entitled the damage caused to the nature and society due to improper use of energy:

"Energy= money and war. Energy, required absolutely for life, is the cause of many wars due to its economic gains. Needless to say, it is not possible to put an end to energy dependence, but through putting an end to each country's dependence on energy, wars can be prevented" (P39)

The example of the chemical aspect of energy:

"Energy is the product that appears through a matter or any reaction" (P8)

However, according to Table 2, the findings of the teacher candidates' drawings related to the concept of energy fall into 6 categories. These can be listed as follows: Biological energy and metabolism (17), energy resources in the nature, types of energy and renewable energy (14), energy for life continuity (6), energy flow, cycle, and related events (15), the relationship of energy to daily life and technology (10) and the damage caused to the nature and society due to improper use of energy (4). When the teacher candidates' drawings related to the concept of energy were analyzed, it was determined that they provided mostly the figures of ATP (6), wind tribune (5), food (4) and plants (4). The examples of the figures provided by the teacher candidates related to the concept of energy are provided in between Figure 2 and 9.

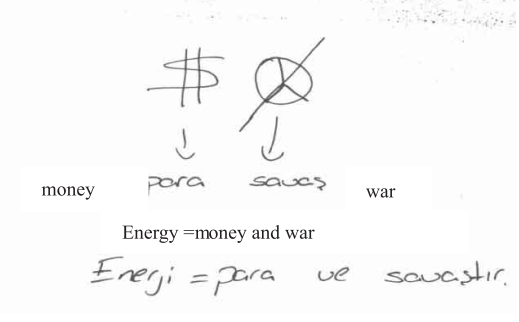


Figure 2: A symbol of money and war, P39.

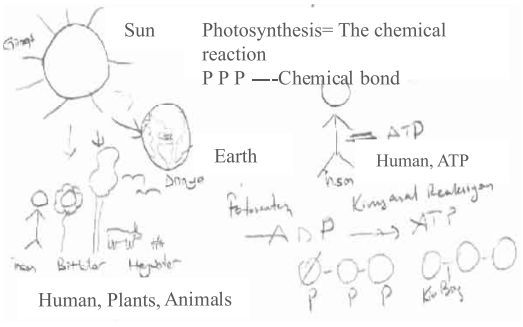


Figure 6: The flow of energy, P25.

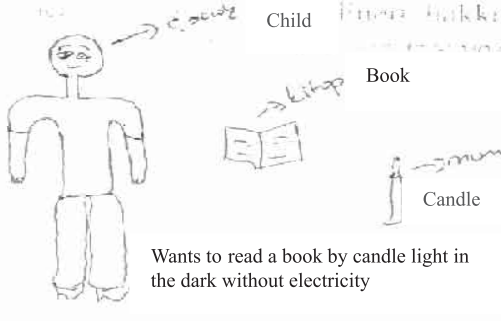


Figure 3: Child / Book / Candle, P3.

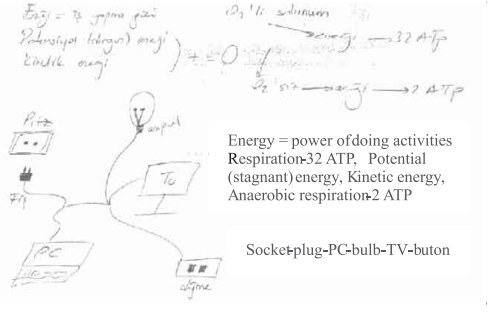


Figure 7: Daily life, P18.

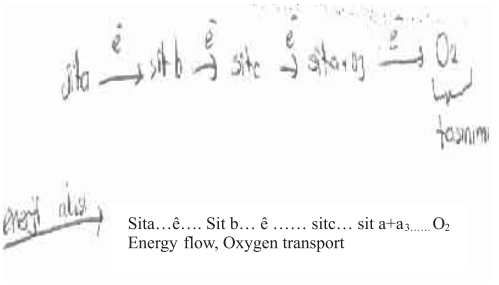


Figure 4: Electron transport system, P30.

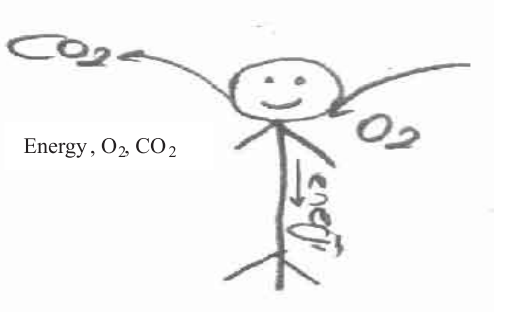


Figure 8: Gas exchange, P6.

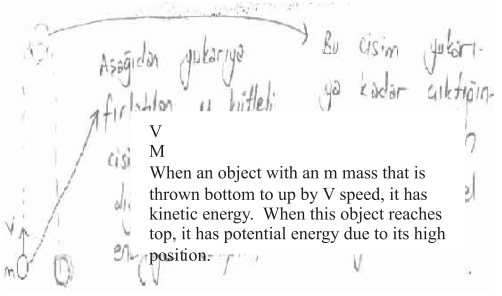


Figure 5: Kinetic energy-potential energy, P28.

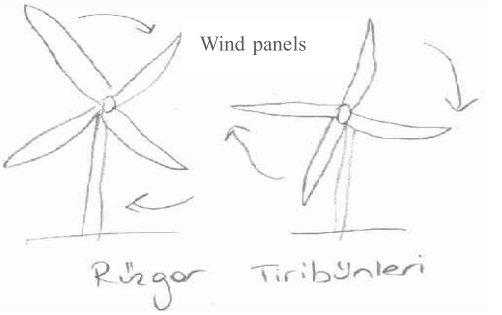


Figure 9: Wind panels, P4.

The Data Collected Through the Semantic Differential Attitude Scale of the Concept of Energy

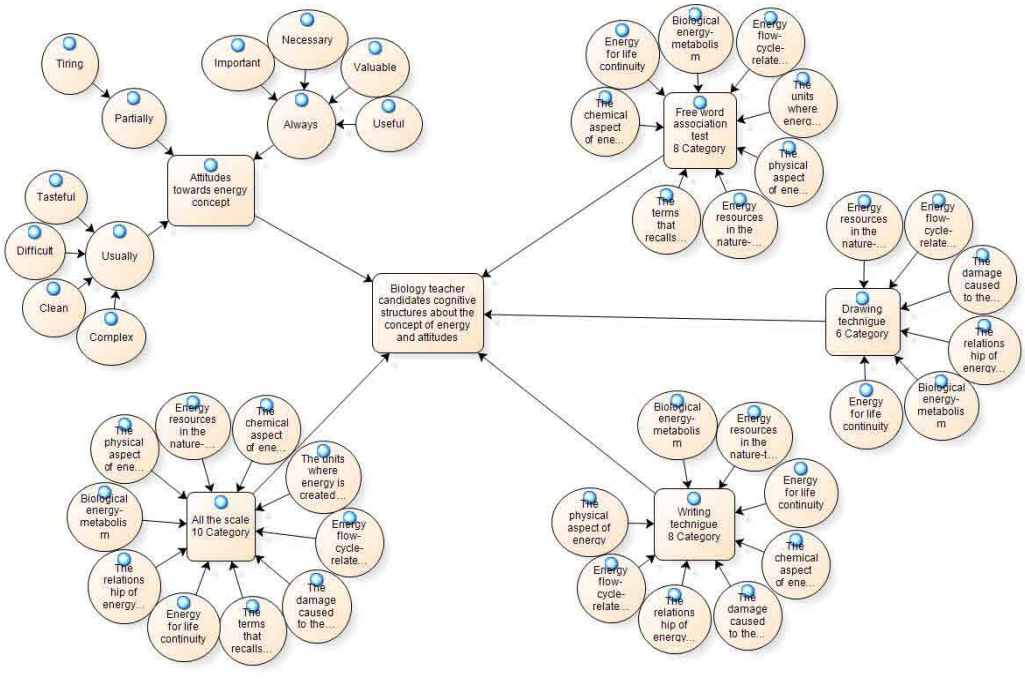
The descriptive values of the data collected on Biology teacher candidates' attitudes towards the concept of energy through the semantic differential attitude scale are provided in Table 3. While it was determined that the teacher candidates generally considered the concept of energy difficult based on the arithmetic mean 3.72, they adopted attitudes as enjoyable 3.77, generally complex 3.81, partly neither tiring nor not tiring 2.81, always valuable 4.75, always necessary 4.84, always useful 4.59, generally clean 3.61 and always important 4.88. Total attitude scores were calculated by averaging the responses for all 9 pairs (mean = 4.42). An overall above 3.5 was defined as a positive attitude, a score between 3.5 and 2.5 was considered neutral, and a score below 2.5 represented a negative attitude (Lohr & Bummer, 1992). Biology teacher candidates' semantic attitudes toward energy were found to be positive. Moreover, while 36.4% of the teacher candidates perceived the concept of energy as neither difficult nor easy, of them, 40.9% considered it as neither enjoyable nor boring, 38.6% as always complex, 36% as neither trying nor not trying, 79.5% as always valuable, 86.4% as always necessary, 72.7% as always useful, 52.3% neither clean nor dirty, and 88.6% as always important.

Table 3. The findings of the descriptive values of the data collected through the semantic differential attitude scale of the concept of energy (N=44).

			Always		Usually		Partially		Usually		Always	
Semantic statements	Mean	SD	n	%	n	%	n	%	n	%	n	%
Difficult-Easy	3.72	1.04	13	29.5	11	25	16	36.4	3	6.8	1	2.3

			Always		Usually		Partially		Usually		Always	
Semantic statements	**Mean**	**SD**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Tasteful-Boring	3.77	.98	13	29.5	11	25	18	40.9	1	2.3	1	2.3
Complex-Simple	3.81	1.12	17	38.6	8	18.2	14	31.8	4	9.1	1	2.3
Tiring-Not Exhausting	2.81	1.36	7	15.9	5	11.4	16	36.4	5	11.4	11	25
Valuable-Worthless	4.75	.53	35	79.5	7	15.9	2	4.5	-	-	-	-
Necessary-Unnecessary	4.84	.42	38	86.4	5	11.4	1	2.3	-	-	-	-
Useful -Not Useful	4.59	.72	32	72.7	6	13.6	6	13.6	-	-	-	-
Clean-Dirty	3.61	.969	11	25	8	18.2	23	52.3	1	2.3	1	2.3
Important-Trivial	4.88	.321	39	88.6	5	11.4	-	-	-	-	-	-

Through using free word-association test and drawing-writing technique and evaluating teacher candidates' views on energy, their cognitive structures were mapped. As indicated in this model, according to the analyses, while 8 categories were determined in the biology teacher candidates' cognitive structures related to energy though free word-associated test, 6 categories in the drawings and 8 categories in the writings were determined through the drawing-writing technique. As a result of the analysis of the data collected through the free-word association test and the drawing-writing technique, 10 categories were determined in total in the biology teacher candidates' cognitive structures related to energy. On the other hand, when the categories obtained through the free word-association test and drawing-writing technique completed by the biology teacher candidates are analyzed, 3 categories appear to be as the most commonly and frequently emerging categories and their cognitive structures are framed within these categories.



Model 1: The model created through the data collected via the free word-association test, the drawing-writing technique, and the semantic differential attitude scale, "Biology teacher candidates' cognitive structures related to energy and attitudes"

Discussion and Implications

The aim of the current study is to investigate Biology teacher candidates' conceptual structures related to energy through using the free word-association test and drawing-writing technique and to determine the semantic differences of their attitudes towards the concept of energy since their cognitive structures related to the concept of energy are important in that these structures help from the nature of biology and the concepts in biology. In the current study, through the data collected using different measurement instruments, the biology teacher candidates' positive and negative connections related to energy and their cognitive structures were revealed.

In this context, as a result of the analysis of the data collected through drawing-writing technique, 8 categories were determined in total. These can be listed as follows: "*biological energy and metabolism", "energy resources in the nature", "types of energy and renewable energy", "energy for life continuity", "the units where energy is generated and used for living things", "physical aspect of energy, energy flow", "energy cycle and related events", the terms that call energy",* and *"chemical aspect of energy".* In this vein, 299 answer words were provided in total.

The data collected through the statements provided by the participants in the drawing-writing technique revealed 8 categories in total. These can be listed as follows: *"biological energy and metabolism", "energy resources in the nature", "types of energy and renewable energy ", "energy flow, cycle and related events", "the relationship of energy with daily life and technology", "the physical aspect of energy", "the damage caused to the nature and society due to improper use of energy",* and *"the chemical aspect of energy". U*nlike the free word-association test, while in the drawing-writing technique, two categories were determined as "*the relationship of energy with daily life*" and *"the damage caused to the nature and society due to improper use of energy"*, in the word association test, unlike drawing-writing technique, the categories entitled *"the units where energy is generated and used"* and *"the terms that calls energy"* were determined. Moreover, in the drawing-writing technique, 8 categories were determined through analyzing the written statements, while through the drawings only 6 categories were determined. The categories that were not determined in the participants' drawings were *"the physical aspect of energy"* and *"the chemical aspect of energy*".

The results suggested that the participants had many misconceptions. In this sense, the important misconceptions as provided by the participants in the free word-association tests were determined as follows:

Energy generation through carbohydrates, proteins, and oils, life continuity is ensured through these: The participant, (P17), provided the following statement regarding this misconception: "*Energy is generated through the breakdown of carbohydrates, protein, and oils, and life continuity is ensured.*" However, living things do not obtain energy just from food substances. The participant/participants considered this as changeable energy. In the study conducted by Lancor (2012), it is stated that university students provided metaphors as a type of changeable energy and exemplified this situation through the consumption of bananas. These two research results are in alignment with each other as for this result.

Only the sun and ATP considered as energy and ATP production only through photosynthesis: Regarding this misconception, the participant, P31, stated that ".... *When we think of energy, ATP and the sun comes into our mind.* "Plants*, as a result of photosynthesis, obtain ATP".* Cepni et. al., (2006) determined the misconception "Energy is generated through photosynthesis" shared by high school students, and through this study, the biology teacher candidates were found to have a similar misconception. When the answer words provided by the participants in the word-association test were analyzed, only the word "glucose" was identified in the category entitled "*biological energy and metabolism*". In the study conducted by Oliveira et. al., (2003), it is stated that as a common misconception, university students provide that only glucose is used as a fuel by ATP. Moreover, in the other studies conducted, it was determined that high school students as wells as biology teachers and biologist had the misconception that ATP that was produced by cells was only provided by glucose (Da Luz, 2008). In these studies, high school students were also stated to have the same misconception (Da Luz et. al., 2008). Barak et. al. (1997) investigated the concept of energy in their study whose participants were university and biology teachers. The results of the study indicate that the terms of energy affect biology concepts. They revealed that there was a

meaningful relationship particularly between biological events and biological bonds. They divided the data collected into four subcategories, components, processes, forces, and laws, respectively. In the category of components, it is indicated that "The participants stating that ATP was a common chemical molecule believed that feelings and opinions were a result of the components of the materials.

Energy can change into one another: Regarding this misconception, the participant, P34, stated that "... Energy is a concept that changes into one another. Such as solar, kinetic, and mechanical energy ..." However, as is widely known, energy does not change into one another but only can be transferred. Trumper, in (1997a, b), indicated that this misconception shared by biology teacher candidates was also observed in biology and primary school teacher candidates' statements. This misconception, discussed and revealed in quite a few studies, was also observed in the statements provided by primary, secondary, high school, and university students, teacher candidates (Watts, 1983; Goldring & Osborn, 1994; Liu et. al., 2002; Boylan, 2008; Hirca et. al., 2008; Liarakou et. al., 2009; Lee & Liu, 2010; Musango & Brent, 2011; Bodzin, 2012; Constantinou & Papadouris, 2012). As a result of this study, it is determined that biology teacher candidates know that energy does not disappear and is preserved. The findings of the current study are in alignment with those of the study conducted by Chabalengula et. al., (2012). In their study, it was revealed that the vast majority of the university students provided definitions of energy, rather than explain energy and that these definitions were due to rote learning. It was further determined that although almost all of the students were aware of energy preservation (energy is not generated or terminated), most of them failed to apply energy concepts in biology.

On the other hand, the misconceptions identified in the data collected through drawing-writing technique were, in general, similar to those determined in the data collected through the free word-association tests. In this context, the important misconception identified in the participants' statements in the drawing-writing technique was determined as follows:

Energy generation through a material or reaction: The participant, P8, stated that "Energy is the output that is generated through a matter or any chemical reaction". However, energy is not generated from a matter or reaction. In the studies conducted, high school students (Ahtee & Varjola, 1998; Niaz, 2006; Ayyildiz & Tarhan, 2012) and university freshmen enrolled in chemistry were observed to have similar misconceptions (Nyachwayaa, 2011).

While the associations determined in the study reflect students' platitudes (image), this situation is discussed in other studies conducted using different concepts and terms (Dikmenli, 2010b). It can be put forward that biology teacher candidates' views of energy are superficial. In the current study, it was determined that biology teacher candidates' level of knowledge was at the expected level in the very first category entitled biological energy and metabolism of 8 categories determined through both word-association test and drawing-writing technique; however, it was also determined that they had some misconceptions regarding energy. These results obtained are, in some respects, in alignment with those revealed by the studies conducted on energy by Oliveria et. al., (2003), Watts (1983), and Kruger (2012).

Although the biology teacher candidates' concepts related to the categories of biological energy and metabolism, energy resources in the nature, types of energy, and renewable energy were not at the expected level, it can be stated that their cognitive structures ensure conceptual validity. In the other studies conducted on university students, it was determined that students' cognitive structures were based on platitudes and imperfect knowledge (Dikmenli, 2010a). The results of this study are similar to those of the studies in the related literature. It was determined that some of the participants did not write any sentence and that some provided meaningless sentences that proved to be mostly related to the types of energy rather than have any associations with the first category.

Some of the important results of the study reveal that some of the participants considered the concept of energy as human-centered, some as a storage model (batter, bulb, sun), some as a component, some as an action (humans' running, weight lifting, commuting between school and home), some as a product (energy generation when chemical bonds are broken down), some as a function (fuel), and some as a flow model. These results are similar to those indicated in the study conducted by Watts (1983). Coban et. al. (2007), in the study conducted with the participation of primary school students, stated that the students thought that a glass of water, sound, battery and alarm clock had energy.

Considering these results, it was determined that biology teacher candidates had closer associations between biological energy and metabolism through the concept of energy. On the other hand, the participants had fewer associations with the chemical and physical aspects of energy, which indicated that biology teacher candidates cannot have interdisciplinary connections. However, as is known, energy is the most commonly used concepts in many disciplines related to each other. It was determined that biology teacher candidates had misconceptions in each category determined as related to the concept of energy. Alternative concepts are due to the fact that the connections between concepts cannot be structured in individuals' minds while they are learning concepts. Unless educators teach the basic characteristics of a concept and the differences between this concept and similar concepts precisely, in days to come students of at various levels will have misconceptions. Before defining a term, educators should first explain it reflecting its basic characteristics and help understand its relationship with other concepts (Wandersee et al., 1994). Thus, educators can prevent students from having misconceptions.

Moreover, according to the results of the current study, it was determined that biological literacy is not at a desired level. Since the statements provided for the writing technique revealed that biology teacher candidates could not go beyond just providing a few platitudes and only focused on the definitions of energy. It is thought-provoking that these candidates to be biology teachers when they graduate are not equipped with necessary knowledge. Biology teacher candidates should develop subjective comments regarding the importance of knowledge of biology, think creatively, ask different questions and process and evaluate knowledge thoroughly. Thus, teaching concepts and conceptual learning should be attached great importance. As stated by Uno and Bybee (1994), *biological literacy should be based on the fundamental facts such as principles in Biology, important concepts in Biology, how human affect biosphere, scientific research methodology, and the historical review of biological concepts. Subjective comments should be geared towards the biological information in scientific research; creative thinking should be encouraged; different questions should be asked, and knowledge should be both evaluated and processed"*. However, according to the results of the current study, while biology teacher candidates were found to have sufficient associations in some of the categories revealed in the study, but not enough association in some, they had some misconceptions stated as "*energy is obtained through food, only the sun and ATP are energy, ATP is only generated through photosynthesis, energy changes to one another, and energy generation through a matter or reaction*". Therefore, the conceptual biological literacy that biology teacher candidates were expected to have could not be determined (Uno & Bybee, 1994). As stated by Kurt et al., (2009), it was determined that the vast majority of the biology teacher candidates did not have biological literacy. It can be also stated that the biology teacher candidates did not have biological literacy.

When the teacher candidates' semantic differences related to the concept of energy were analyzed, it was determined that while they generally adopted attitudes towards the concept of energy as "difficult, enjoyable, complex and clean", they always adopted attitudes as "valuable, necessary, useful, and important". They were found to adopt attitudes as "sometimes" towards the adjectives ""tiring-not tiring". The Biology teacher candidates' semantic attitudes toward energy were found to be positive. Furthermore, while 36.4% of the teacher candidates perceived the concept of energy as neither difficult nor easy, of them, 40.9% as neither enjoyable nor boring, 38.6% as always complex, 36.% as neither trying nor not trying, 79.5% as always valuable, 86.4% as always necessary, 72.7% as always useful, 52.3% neither clean nor dirty, and 88.6% as always important. Considering both arithmetic means and percentages, it was determined that the most attitudes related to the concept of energy adopted by the teacher candidates was towards the adjective "always important".

Conclusions

In conclusion, the results of the current study that support each other were obtained in this study in which the biology teacher candidates' cognitive structures were determined through using different data collection instruments. In this concept, although different measurement tools were used, while determining the themes in common, different themes that support each other were also determined.

Moreover, biology teacher candidates' semantic attitudes towards energy were found to be positive. It is suggested that to determine cognitive structures, further research be conducted selecting different research participants, different concepts and using different data collection instruments.

References

Ahtee, M., & Varjola, I. (1998). Students' understanding of chemical reaction. *International Journal of Science Education, 20,* 305-316.

Ajzen I., & Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin, 84,* 888-918.

Al Khawaldeh, S. A., & Al Olaimat, A. M. (2010). The contribution of conceptual change texts accompanied by concept mapping to eleventh-grade students' understanding of cellular respiration concepts. *Journal Science Education Technology, 19,* 115-125.

Amir, R., & Tamir, P. (1994). In-depth analysis of misconceptions as a basis for developing research-based remedial instruction: The case of photosynthesis. *The American Biology Teacher, 56* (2), 94-100.

Anderson, L.W. (1988). Attitude measurement: Attitudes and their measurement. In Keeves, J. P. (Ed.), *Educational research methodology and measurement: An international handbook* (pp. 227-256). New York: Pergamon Press.

Atasoy, B. (2004). Fen ogrenimi ve ogretimi (Science learning and teaching). Ankara: Asil Yayinevi.

Atasoy, B., Kadayifci, H., & Akkus, H. (2007). Revealing the creative ideas through students' drawings and statements. *Journal of Turkish Educational Sciences*), *5* (4), 679–700.

Ayas, A., Cepni, S., Johnson, D., & Turgut, M.F. (1997). *Kimya öğretimi (Chemistry education).* Ankara: YÖK documents.

Aydogan, S., Gunes, B., & Gulcicek, C. (2003). The misconceptions about heat and temperature. *Gazi University Journal of Gazi Education Faculty*, *23* (2), 111-124.

Ayyildiz, Y., & Tarhan, L. (2012). The effective concepts on students' understanding of chemical reactions and energy. *Hacettepe University Journal of Education, 42,* 72-83.

Bacanak, A., Kucuk, M., & Cepni, S. (2004). Determining primary school students' misconceptions about photosynthesis and respiration: Trabzon sample. *Ondokuz Mayis University Journal of Education, 17*, 67–80.

Backett-Milburn, K., & McKie, L. (1999). A critical appraisal of the draw and write technique. *Health Educatıon Research Theory & Practice, 14* (3), 387–398.

Bagozzi, R. P., & Burnkrant, R. E. (1985). Attitude organization and attitude-behavior relation: A reply to Dillon and Kumar. *Journal of Personality and Social Psychology*, *49* (1), 47-57.

Bahar, M., Johnstone, A. H., & Hansell, M. H. (1999). Revisiting learning difficulties in biology. *Journal of Biological Education*, *33,* 84-86.

Bahar, M., Johnstone, A.H., & Sutcliffe, R.G. (1999). Investigation of students' cognitive structure in elementary genetics through word association tests. *Journal of Biological Education*, *33*, 134-141.

Bahar, M., & Ozatli, N.S. (2003). Investigating high school freshman students' cognitive structures about the basic components of living things through word association test method. *Journal of the Institute of Science and Technology of Balikesir University*, *5* (1), 75-85.

Bahar, M., Nartgun, Z., Durmus, S. & Bicak, B. (2006). *Geleneksel ve alternatif olcme ve degerlendirme ogretmen el kitabi* (Traditional and alternative assessment and evaluation of teachers' manual). Ankara: Pegem A Publishing.

Bahar, M. (2003). Misconceptions in biology education and conceptual change strategies. *Educational Sciences: Theory & Practice*, *3* (1) 55-64.

Bahar, M., Ozel, M., Prokop, P., & Usak, M. (2008). Science student teachers' ideas of the heart. *Journal of Baltic Science Education, 7* (2), 1648-3898.

Barak, J. (1996). *A qualitative thermodynamic approach to teaching energy, as part of the Biology curriculum at high school.* Dissertation thesis, Ben-Gurion University, Beer-Sheva, Israel.

Barak, J., Gorodetsky, M., & Chipman, D. (1997). Understanding of energy in biology and vitalistic conceptions. *International Journal of Science Education, 19* (1), 21–30.

Barak, J., Sheva, B., Gorodetsky, M., & Gurion, B. (1999). As `process' as it can get: Students' understanding of biological processes. *International Journal of Science Education, 21* (12), 1281- 1292.

Barraza, L. (1999). Children's drawings about the environment. *Environmental Education Research, 5* (1), 49-66.

Barrow, L. H., & Morrisey, J. T. (1987). Ninth-grade students' attitudes toward energy: a comparison between Maine and New Brunswick. *Journal of Environmental Education 18* (3), 15–21.

Baser, M. (2004). Effect of conceptual change oriented instruction on students' understanding of heat and temperature concepts. *Journal of Maltese Education Research*, *4* (1), 64–79.

Bisconti, A. S. (2000). Environmental concerns and changing attitudes. *Progress in Nuclear Energy*, *37* (1), 77-80.

Bloom, S. B. (1979). *Human characteristics and school learning.* New York: McGraw-Hill.

Bodzin, A. (2012). Investigating urban eighth-grade students' knowledge of energy resources. *International Journal of Science Education, 34* (8), 1255-1275.

Bohner, G., & Wanke, M. (2002). *Attitude and attitude change.* New York: Psychology Press.
Boo, H. K., & Watson, J. R. (2001). Progression in high school students' (aged 16–18) conceptualizations about chemical reactions in solution. *Science Education*, *85*, 568–585.
Boylan, C. (2008). Exploring elementary students' understanding of energy and climate change. *International Electronic Journal of Elementary Education, 1* (1), 1-15.
Brown, M. H., & Schwartz, R. S. (2009). Connecting photosynthesis and cellular respiration: Preservice teachers' conceptions. *Journal of Research in Science Teaching, 46* (7), 791-812.
Cakiroglu, J., & Boone, W. J. (2002). Preservice elementary teachers' self-efficacy beliefs their conceptions of photosynthesis and inheritance. *Journal of Elementary Science Education, 14* (1), 1-14.
Carlsson, B. (2002). Ecological understanding 1: Ways of experiencing photosynthesis. *International Journal of Science Education, 24* (7), 681–699.
Cepni, S., Tas, E., & Kose, S. (2006). The effects of computer-assisted material on students' cognitive levels, misconceptions and attitudes towards science. *Computers & Education, 46,* 192–205.
Ceylan, E., & Geban, O. (2010). Promoting conceptual change in chemical reactions and energy concepts through the conceptual change oriented instruction. *Education and Science, 35* (157), 46-54.
Chabalengula, V. M., Sanders, M., & Mumba, F. (2012). Diagnosing students' understanding of energy and its related concepts in biological context. *International Journal of Science and Mathematics Education, 10* (2), 241-266.
Coban, G. U., Aktamis, H., & Ergin, O. (2007). The views of 8th grade students about energy. *Kastamonu Education Journal, 15* (1), 175-184.
Coll, R. K., & Taylor, N. (2001). Alternative conceptions of chemical bonding held by upper secondary and tertiary students. *Research in Science and Technological Education, 19* (2), 171–191.
Constantinou, C. P., & Papadouris, N. (2012). Teaching and learning about energy in middle school: an argument for an epistemic approach. *Studies in Science Education, 48* (2), 161–186.
Da Luz, M. R. M. P. (2008). Glucose as the sole metabolic fuel: a study on the possible influence of teachers' knowledge on the establishment of a misconception among Brazilian high school students. *Advances in Physiology Education, 32* (3), 225-230.
Da Luz, M. R. M. P., Oliveira, G. A., Sousa, C. R., & Da Poian, A. T. (2008). Glucose as the sole metabolic fuel: the possible influence of formal teaching on the establishment of a misconception about energy-yielding metabolism among students from Rio de Janeiro, Brazil. *Biochemistry and Molecular Biology Education, 36* (6), 407–416.
Daskolia, M., Flogaitis, E., & Papageorgiou, E. (2006). Kindergarten teachers' conceptual framework on the ozone layer depletion. Exploring the associative meanings of a global environmental issue. *Journal of Science Education and Technology, 15* (2), 168-178.
Dekkers, P. J. J. M., & Thijs, G. D. (1998). Making productive use of students' initial conceptions in developing the concept of force. *Science Education*, *82*, 31-51.
Dikmenli, M. (2010a). Biology student teachers' conceptual frameworks regarding biodiversity. Education, *130* (3), 479-489.
Dikmenli, M. (2010b). Undergraduate biology students' representations of science and the scientist. *College Student Journal, Part B, 44* (2), 579-588.
Dikmenli, M. (2010c). Biology students' conceptual structures regarding global warming. *Energy Education Science and Technology, Part B, 2* (1&2), 21-38
Dove, J. E., Everett, L. A., & Preece, P. F. W. (1999). Exploring a hydrological concept though children's drawings. *International Journal of Science Education, 21* (5), 485-497.
Dulski, R. E., Dulski, R.E., & Raven, J. R. (1995). Attitudes toward nuclear energy: One potential path for achieving scientific literacy. *Science Education, 79* (2), 167–187.
Edens, K. M., & Potter, E. (2003). Using descriptive drawings as a conceptual change strategy in elementary science. *School Science and Mathematics, 103* (3), 135-144.
Ekici, F., Ekici, E., & Aydin, F. (2007). Utility of concept cartoons in diagnosing and overcoming misconceptions related to photosynthesis. *International Journal of Environmental and Science Education, 2* (4), 111-124.
Ekici, G., Gokmen, A., Atik, A. D., Cimen, O., Altunsoy, S., & Sahin, H. (2013). Scale for attitudes of secondary education students towards nuclear power: A scale development study. *Energy Education Science and Technology, Part B, 5* (1), 395-406.
Ertas, H., Sen, A. I., & Parmasizoglu, A. (2011). The effects of out-of school scientific activities on 9th grade students' relating the unit of energy to daily life. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 5* (2), 178-198.
Faiers, A., & Neame, C. (2006). Consumer attitudes towards domestic solar power systems. *Energy Policy* , *34* (14), 1797-1806.
Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, ıntention and behavior: An ıntroduction to theory and research.* reading, MA: Addison-Wesley.
Garland, H.D. (2005). Evidence of witnessed community violence in children's drawings. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 65* (12-B), 6650.
Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers an introduction*. London: Longman Group Ltd.

Griffard, P. B., & Wandersee, J.B. (2001). The two tier instrument on photosynthesis: What does it diagnose? *International Journal of Science Education, 23* (10), 1039-1052.
Goldring, H., & Osborne, J. (1994). Students' difficulties with energy and related concepts. *Physic Education, 29* (1), 26-32.
Gunes, M. H. (2011). Modelling about energy transformation in living organisms. *Procedia-Social and Behavioral Sciences, 15* (2011), 1183–1187.
Gunes, M. H., Gunes, O., & Hoplan, M. (2011). The using of computer for elimination of misconceptions about photosynthesis. *Procedia-Social and Behavioral Science, 15* (2011), 1130–1134.
Harrison, A. G., & Treagust, D. (2000). Learning about atoms, molecules, and chemical bonds: A case study of multiple-model use in grade 11 chemistry. *Science Education, 84* (3), 352–381.
Hirca, N., Calik, M., & Akdeniz, F. (2008). Investigating grade 8 students' conceptions of "energy" and related concepts. *Journal of Turkish Science Education, 5* (1), 75-87.
Hirca,N., Calik, M., & Seven, S. (2011). Effects of guide materials based on 5e model on students' conceptual change and their attitudes towards physics: a case for 'work, power and energy' unit. *Journal of Turkish Science Education, 8* (1), 139-152.
Hinman, G. W., Rosa, E. A., Kleinhesselink, R. R., & Lowinger, T. C. (1993). Perception of nuclear and other risks in Japan and the United States. *Risk Analysis, 13* (4), 449–455.
Hovardas, T., & Korfiatis, K. J. (2006). Word associations as a tool for assessing conceptual change in science education. *Learning and Instruction, 16* (5), 416-432.
Jordan, R., & Duncan, R. G. (2009). Student teachers' images of science in ecology and genetics. *Journal of Biological Education, 43* (2), 62-69.
Kagitcibasi, C. (2010). *Gunumuzde insan ve insanlar: Sosyal psikolojiye giris* (Human and humans: An introduction to social psychology). İstanbul: Evrim Publishing.
Kartal, T., Ozturk, N., & Yalvac, H. G. (2011). Misconceptions of science teacher candidates about heat and temperature. *Procedia-Social and Behavioral Sciences, 15*, 2758–2763.
Keles, E., & Kefeli, P. (2010). Determination of student misconceptions in "photosynthesis and respiration" unit and correcting them with the help of CAI material. *Procedia-Social and Behavioral Sciences, 2*, 3111–3118.
Kirikkaya, E. B., & Gullu, D. (2008). Fifth grade students' misconceptions about heat-temperature and evaporation-boiling. *Elementary Education Online, 7* (1), 15-27.
Komiya, I., Torii, H., Fujii, Y., & Hayashizaki, N. (2008). Relationship between students' interests in science and attitudes towards nuclear power generation. *Progress in Nuclear Energy, 50,* 719-727.
Kose, S., Ayas, A., & Usak, M. (2006). The effect of conceptual change texts instructions on overcoming prospective science teachers' misconceptions of photosynthesis and respiration in plants. *International Journal of Environmental and Science Education, 1* (1), 78-103.
Kose, S. (2008). Diagnosing student misconceptions: Using drawings as a research method. *World Applied Sciences Journal, 3* (2), 283-293.
Kostova, Z., & Radoynovska, B. (2008). Word association test for studying conceptual structures of teachers and students. *Bulgarian Journal of Science and Education Policy, 2* (2), 209-231.
Kostova, Z. & Radoynovska, B. (2010). Motivating students' learning using word association test and concept maps. *Bulgarian Journal of Science and Education Policy, 4* (1), 62-98.
Kruger, C. (1990). Some primary teachers' ideas about energy. *Physic Education, 25* (2), 86-91.
Kuhn, D. J. (1979). Study of the attitudes of secondary school students toward energy-related issues, *Science Education, 63* (5), 609–620.
Kurnaz, M. A., & Calik, M. (2009). A thematic review of 'energy' teaching studies: Focuses, needs, methods, general knowledge claims and implications. *Energy Education Science and Technology Part B: Social and Educational Studies*, *1* (1), 1-26.
Kurt, H., Kaya, B., Ates, A., & Kilic, S. (2009). *T*he biological literacy of biology teacher candidates. *Selcuk University Journal of Ahmet Kelesoglu Education Faculty, 27*, 17-30.
Lancor, R. A. (2012). Using student-generated analogies to investigate conceptions of energy: A multidisciplinary study. *International Journal of Science Education, 2012*, 1-23.
Lawrenz, F., & Dantchik, A. (1985). Attitudes toward energy among students in grades 4, 7 and high school. *School Science and Mathematics, 85* (3), 189–202.
Lee, H. S., & Liu, O. L. (2010). Assessing learning progression of energy concepts across middle school grades: The knowledge integration perspective. *Science Education, 94* (4), 665–688.
Lenton, G. M., & McNeil, J. (1993). Primary school teachers' understanding of biological concepts: selected research findings. *British Journal of In-Service Education, 19* (2), 27-34.
Levin, I., & Bus, A. G. (2003). How is emergent writing based on drawing? Analyses of children's products and their sorting by children and others. *Developmental Psychology, 39* (5), 891–905.
Liarakou, G., Gavrilakis, C., & Flouri, E. (2009). Secondary school teachers' knowledge and attitudes towards renewable energy sources. *Journal of Science Education and Technology, 18* (2), 120–129.
Lin C. Y., & Hu, R. (2003). Students' understanding of energy flow and matter cycling in the context of the food chain,

photosynthesis, and respiration. *International Journal of Science Education*, *25* (12), 1529-1544.
Liu, X., Ebenezer, J., & Fraser, D. M. (2002). Structural characteristics of university engineering students' conceptions of energy. *Journal of Research in Science Teaching*, *39* (5), 423-441.
Liu, X., & McKeough, A. (2005). Developmental growth in students' concept of energy: Analysis of selected items from the TIMSS database. *Journal of Research in Science Teaching, 42* (5), 493-517.
Lloyd, H. B., & Morrisey, J. T. (1987). Ninth-grade students' attitudes toward energy: A comparison between Maine and New Brunswick. *The Journal of Environmental Education, 18* (3), 15-21.
Lohr, V. I., & Bummer, L. H. (1992). Assessing and influencing attitudes toward water-conserving landscape. *Hort-Technology*, *2* (2), 253-256.
Lutzenhiser, L. (1993). Social and behavioral aspects of energy use. *Annual Review of Energy and the Environment,* 18 (1), 247-89.
Midden, C. J. H., & Verplanken, B. (1990). The stability of nuclear attitudes after Chernobyl. *Journal of Environmental Psychology, 10* (2), 111–119.
Muller, D. J. (1986). *Measuring Social Attitudes: A Handbook for Researchers and Practitioners.* New York: Teachers College Press.
Musango, J. K., & Brent, A. C. (2011). A conceptual framework for energy technology sustainability assessment. *Energy for Sustainable Development, 15* (1), 84-91.
Nakleh, M. B. (1992). Why some students don't learn chemistry? *Journal of Chemical Education*, *69* (3), 191-196.
Nakiboglu, C. (2008). Using word associations for assessing nonmajor science students' knowledge structure before and after general chemistry instructions: The case of atomic structure. *Chemical Educational Research Practice, 9*, 309–322.
Niaz, M. (2006). Can the study of thermo chemistry facilitate students' differentiation between heat energy and temperature? *Journal of Science Education and Technology*, *15* (3), 269-276.
Nicoll, G. A. (2001). Report of undergraduates' bonding misconception. *International Journal of Science Education*, *23* (7), 707-730.
Nyachwayaa, J. M., Mohameda, A. R., Roehriga, G. H. Woodb, N. B., Kernc, A. L., & Schneiderd, J. L. (2011). The development of an open-ended drawing tool: an alternative diagnostic tool for assessing students' understanding of the particulate nature of matter. *Chemistry Education Research and Practice, 12* (2), 121–132.
Nyrud, A. Q., Roos, A., & Sande, J. B. (2008). Residential bioenergy heating: A study of consumer perceptions of improved woodstoves. *Energy Policy, 36* (8), 3169-3176.
Oliveira, G. A., Sousa, C. R., Da Poian, A. T., & Da Luz, M. R. M. P. (2003). Students' misconception about energy-yielding metabolism: Glucose as the sole metabolic fuel. *Advances in Physiology Education, 27* (3), 97-101.
Osborne, R. J., & Wittrock, M. C. (1983). Learning Science: A generative process. *Science Education*, *67* (4), 489-508.
Owens, S., & Driffill, L. (2008). How to change attitudes and behaviours in the context of energy. *Energy Policy, 36*, 4412–4418.
Ozatli, N. S., & Bahar, M. (2010). Revealing students' cognitive structures regarding excretory system by new techniques. *The Journal of Abant Izzet Baysal University*, *10* (2), 9-26.
Ozdemir, N., & Cobanoglu, E. O. (2008). Prospective teachers' attitudes towards the use of nuclear energy and the construction of nuclear plants in Turkey. *Hacettepe University Journal of Education, 34,* 218-232.
Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd Ed.). London: Sage Publications, Inc.
Piko, B. F., & Bak, J. (2006). Children's perceptions of health and illness: images and lay concepts in preadolescence. *Health Education Research, 21* (5), 643-653.
Pluhar, Z. F., Piko, B. F., Kovacs, S., & Uzzoli, A. (2009). Air pollution is bad for my health: Hungarian children's knowledge of the role of environment in health and disease. *Health & Place, 15,* 239-246.
Poggenpoel, M., & Myburgh, C. (2003). The researcher as research instrument in educational research: A possible threat to trustworthiness? Education, *124* (2), 418-421.
Pridmore, P., & Bendelow, G. (1995). Images of health: Exploring beliefs of children using the 'draw-and-write' technique. *Health Education Journal, 54* (4), 473–88.
Prokop, P., Fancovicová, J., & Tunnicliffe, S. D. (2009). The effect of type of instruction on expression of children's knowledge: How do children see the endocrine and urinary system? *International Journal of Environmental & Science Education, 4* (1), 75-93.
Rennie, L. J., & Jarvis, T. (1995). English and Australian children's perceptions about technology. *Research Science Technology Education, 13* (1), 37-52.
Roberts, P., Priest, H., & Traynor, M. (2006). Reliability and validity in research. *Nursing Standard*, *20* (44), 41-45.
Russel, J., Hollander, S. (1975). A biology attitude scale. *The American Biology Teacher, 37* (5), 270-273.
Sagdic, D., Bulut, O., Korkmaz, S., Boru, S., Ozturk, E., & Cavak, S. (2007). *Ortaöğretim 10. sınıf biyoloji ders kitabı (Secondary education biology textbook- 10th grade).* Ankara: MEB Publishing.
Sahan, B. Y. & Tekin, L. (2007). *Ortaöğretim 10. sınıf fizik ders kitabı (Secondary education physics textbook-10th grade).* İzmir: Zambak Publishing.
Sato, M., & James, P. (1999)."Nature" and "environment" as perceived by university students and their supervisors. *International Journal of Environmental Education and Information, 18* (2), 165-172.

Seyihoglu, A., & Yarar, S. (2010). Attitude scale towards nuclear energy: Scale development, reliability and validity study II. International Turkish Educational Research Congress. Antalya, Turkey.

Shenton, A. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22* (2004), 63-75.

Shepardson, D. P., Wee, B., Priddy, M., & Harbor, J. (2007). Students' mental models of the environment. *Journal of Research in Science Teaching, 44* (2), 327–348.

Stylianidou, F., Ormerod, F., & Ogborn, J. (2002). Analysis of science textbook pictures about energy and pupils' readings of them. *International Journal of Science Education*, *24* (3), 257-283.

Svedholm, A. M., & Lindeman, M. (2012). Healing, mental energy in the physics classroom: energy conceptions and trust in complementary and alternative medicine in grade 10–12 students. *Science & Education, 2012*, 1-18.

Tan, K. C., & Treagust, D. (1999). Evaluating students' understanding of chemical bonding. *School Science Review, 81* (294), 75–84.

Tatar, N., & Koray, O. C. (2005). Determination of the misconceptions of the 8th grade students in primary school about "genetics" unit. *Kastamonu Education Journal, 13* (2), 415-426.

Tekkaya, C., & Balci, S. (2003). Determined students' misconceptions photosynthesis and respiration. *Hacettepe University Journal of Education, 24*, 101–107.

Tezbasaran, A. (1996). *Likert tipi olcek gelistirme kilavuzu* (Guide for developing Likert-style scales). Ankara: Turkish Psychological Association Publications

Trefil, J., & Hazen, R. M. (2004). *Physics matters: an introduction to conceptual physics*. Wiley, New York.

Trumper, R. (1997a). A survey of conception of energy of Israeli pre-service high school biology teachers. *International Journal of Science Education, 19* (1), 31–46.

Trumper, R. (1997b). The need for change in elementary school teacher training: the case of the energy concept as an example. *Educational Research, 39* (2), 157-174.

Uno, E.G., & Bybee, W.R. (1994). Understanding the dimensions of biological literacy. *BioScience, 44* (8), 553-557.

Vlahov, S. J., & Treagust, D. F. (1988). Students' knowledge of energy and attitudes to energy conservation. *School Science and Mathematics, 88* (6), 452–458.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 177-210). NY: Macmillan.

Wang, J. (2004). Development and validation of a two-tier instrument to examine understanding of internal transport in plants and the human circulatory system. *International Journal of Science and Mathematics Education, 2* (2), 131-157.

Watts, D. M. (1983). Some alternative views of energy. *Physic Education, 18* (5), 213-217.

White, R., & Gunstone, R. (1992). *Probing understanding.* London: The Falmer Press.

Yang, F. Y., & Anderson, O. R. (2003). Senior high school students' preference and reasoning modes about nuclear energy use. *International Journal of Science Education, 25* (2), 221–244.

Yayla, R., G., & Eyceyurt, G. (2011). Mental models of pre-service science teachers about basic concepts in chemistry. *Western Anatolia Journal of Educational Sciences, 2011*, 285-294.

Yenilmez, A., & Tekkaya, C. (2006). Enhancing students' understanding of photosynthesis and respiration in plant through conceptual change approach. *Journal of Science Education and Technology, 15* (1), 81-87.

Yesilyurt, M. (2006). High school students' views about heat and temperature concepts. *International Journal of Environmental and Science Education, 1* (1), 1-24.

Yorek, N. (2007). Determination of student conceptual understanding of cell using students drawings at grade 9 and 11. Dokuz Eylul University *Journal of Education*, *22* (2007), 107-114.

Yildirim, A., & Simsek, H. (2006). *Sosyal bilimlerde nitel araştırma yontemleri (qualitative research methods in Social Sciences)*. Ankara: Seckin Yayincilik.

Received: *February 05, 2013* Accepted: *May 30, 2013*

Hakan Kurt PhD., Assistant Professor, Biology Department, Ahmet Kelesoglu Education Faculty, Necmettin Erbakan University, Konya, Turkey.
Fax: +90-332-3238225.
E-mail: kurthakan1@gmail.com
Website: http://www.konya.edu.tr/